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Peng et al.

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(54) **FLEXIBLE ELECTRONIC DEVICE**

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(51) **Int. Cl.**

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H05K 1/18	(2006.01)
G09F 9/33	(2006.01)
G09F 13/22	(2006.01)

(52) **U.S. Cl.**

CPC ***H05K 1/028*** (2013.01); ***G09F 9/33*** (2013.01); ***G09F 13/22*** (2013.01); *H05K 1/189* (2013.01); *H05K 2201/09063* (2013.01); *H05K 2201/10106* (2013.01); *H05K 2201/10128* (2013.01)

(58) **Field of Classification Search**

CPC H05K 1/0278; H05K 1/0271; H01L 27/15
USPC 361/681
See application file for complete search history.

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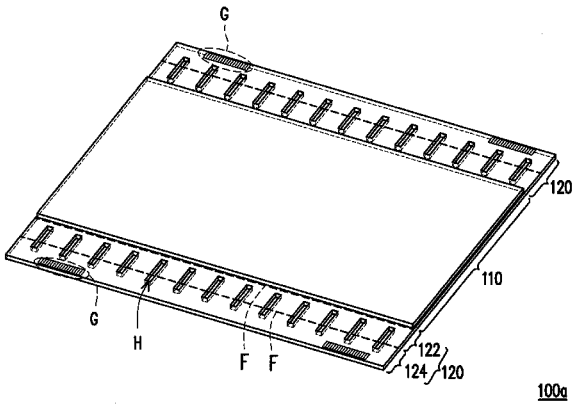
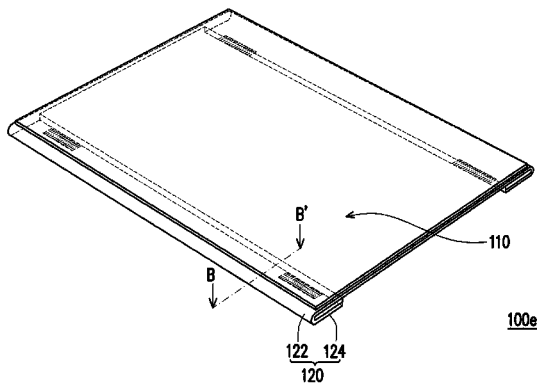
(57) **ABSTRACT**

A flexible electronic device including a component portion and at least one folded portion connected to the component portion is provided. The flexible electronic device has a plurality of flexed lines located on the single folded portion and a plurality of stress relief holes, wherein the stress relief holes are separated from each other, and at least a part of the stress relief holes is located on at least one of the flexed lines.

13 Claims, 14 Drawing Sheets





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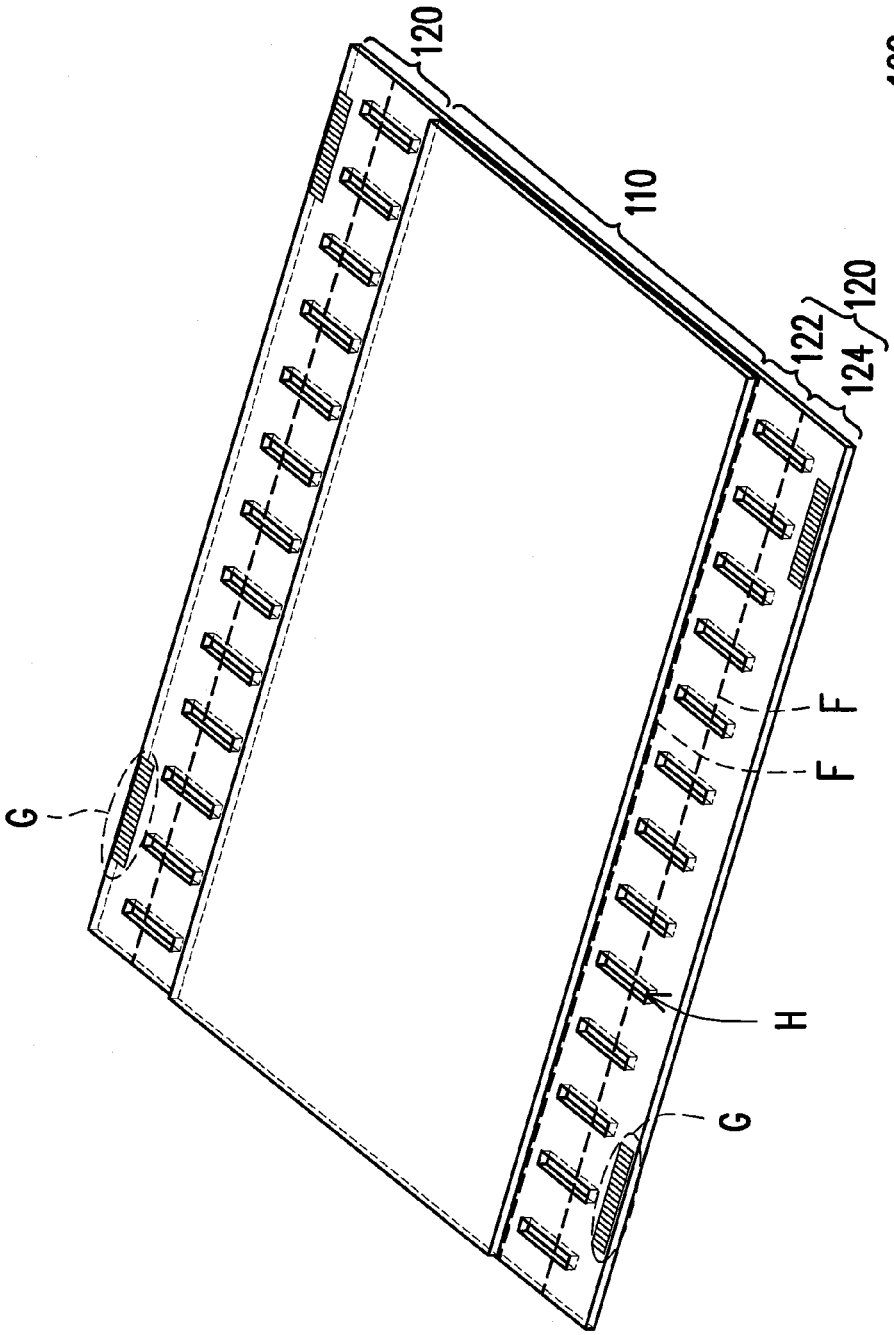

FIG. 1

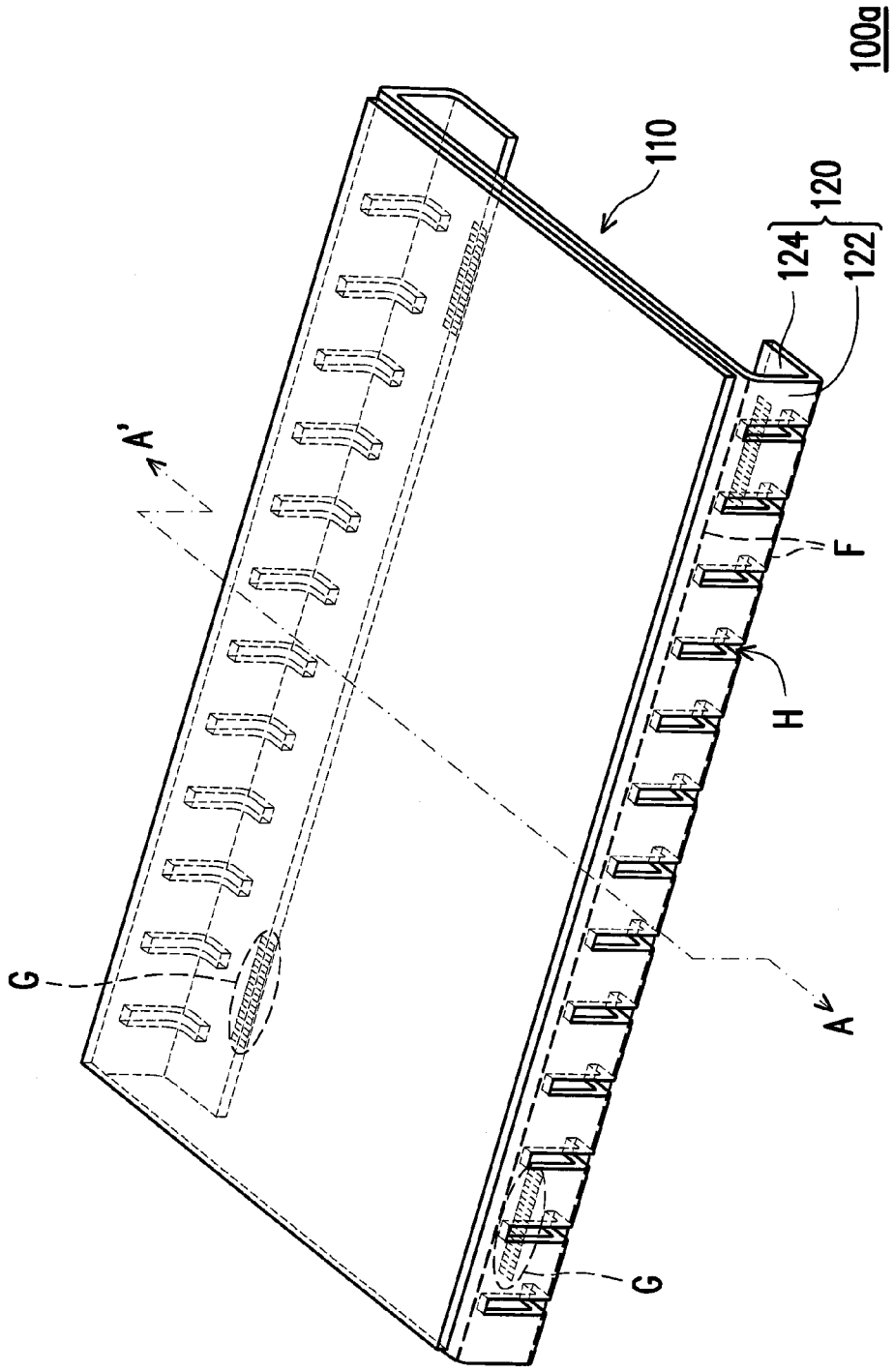

FIG. 2

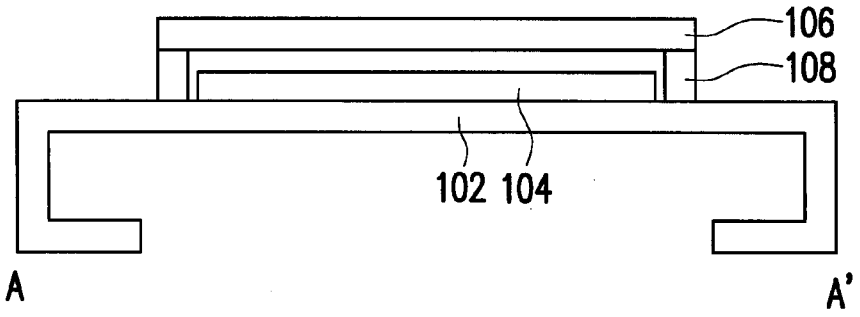

FIG. 3A

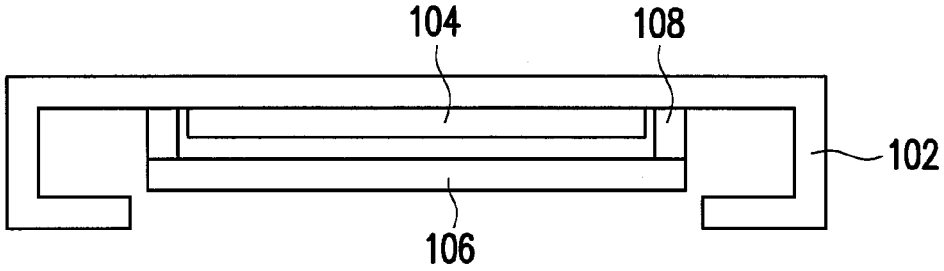

FIG. 3B

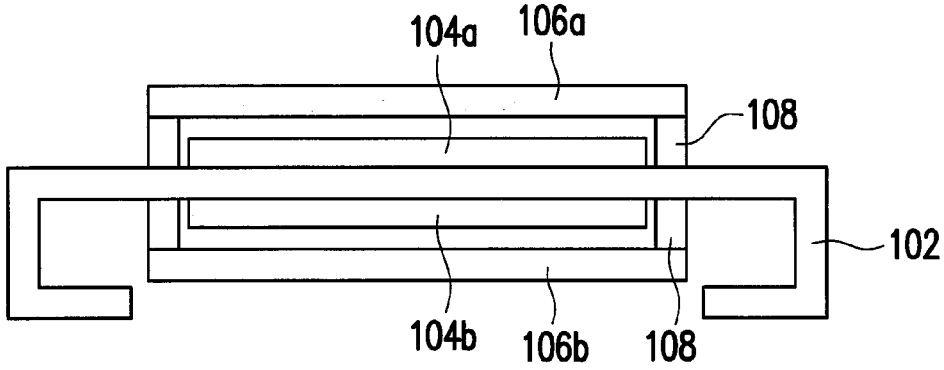

FIG. 3C

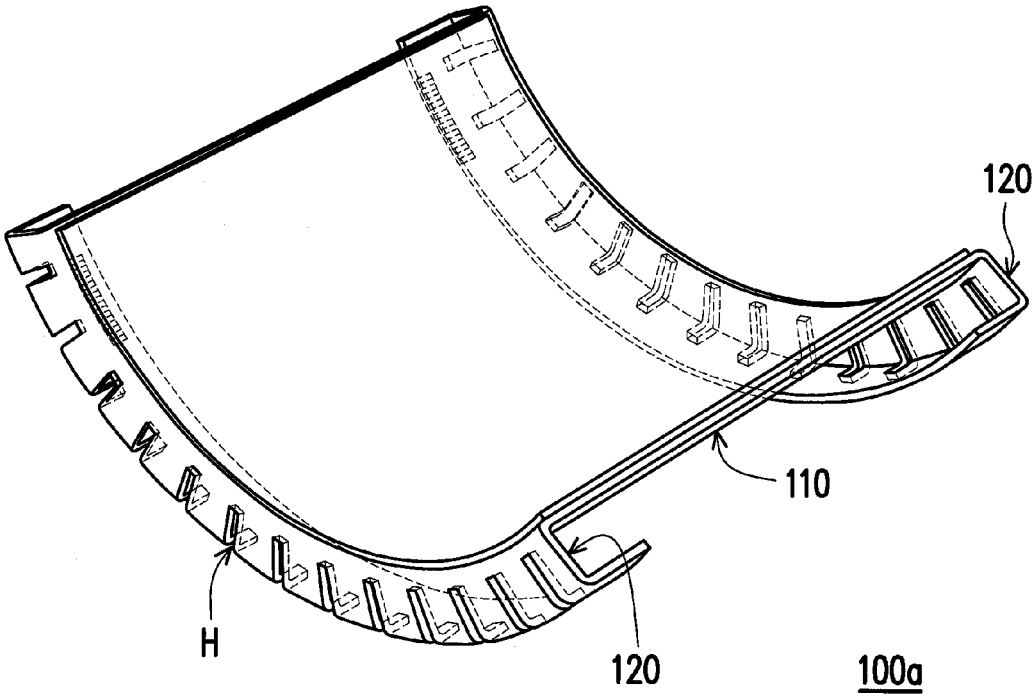

FIG. 4

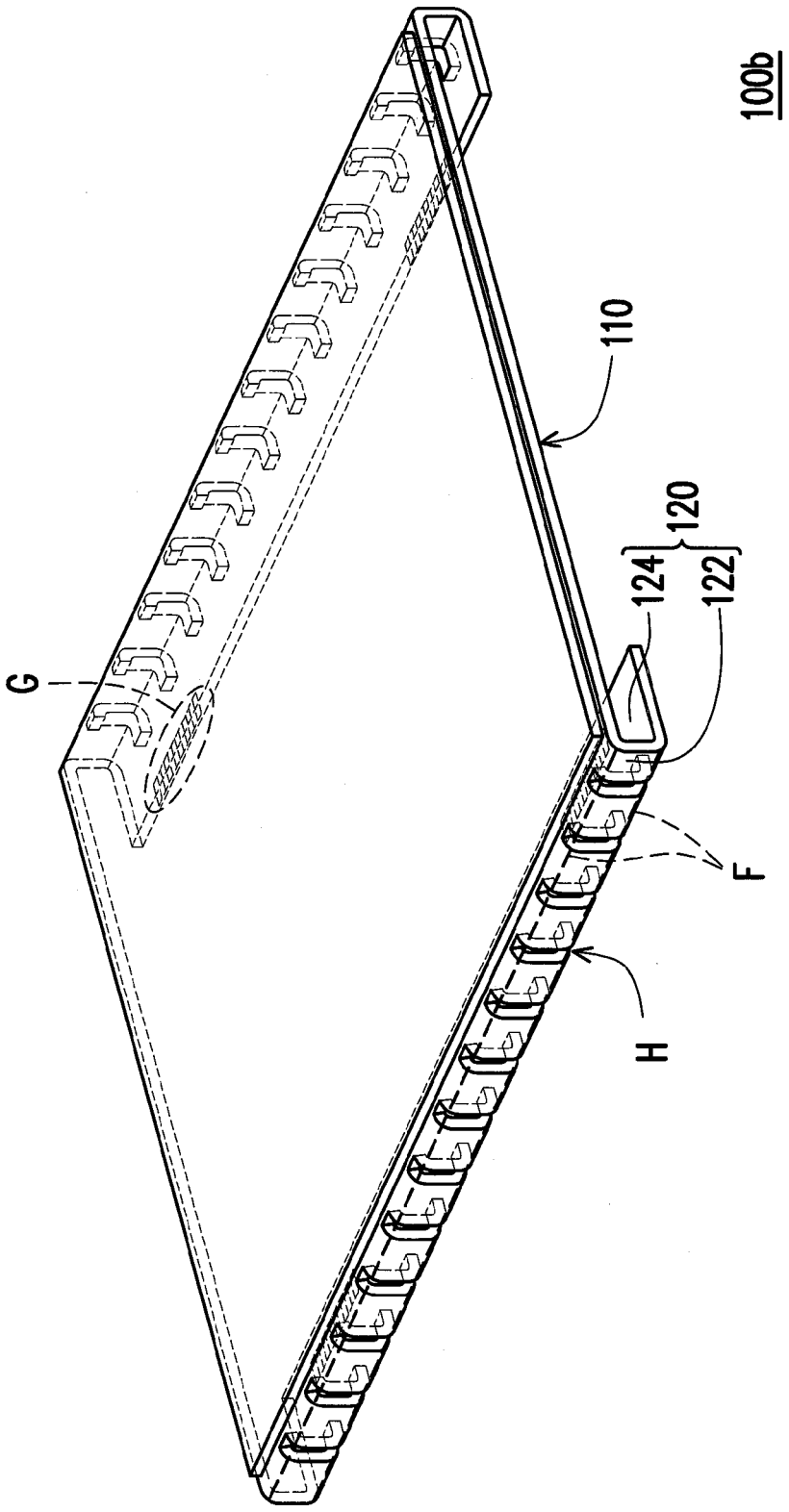

FIG. 5

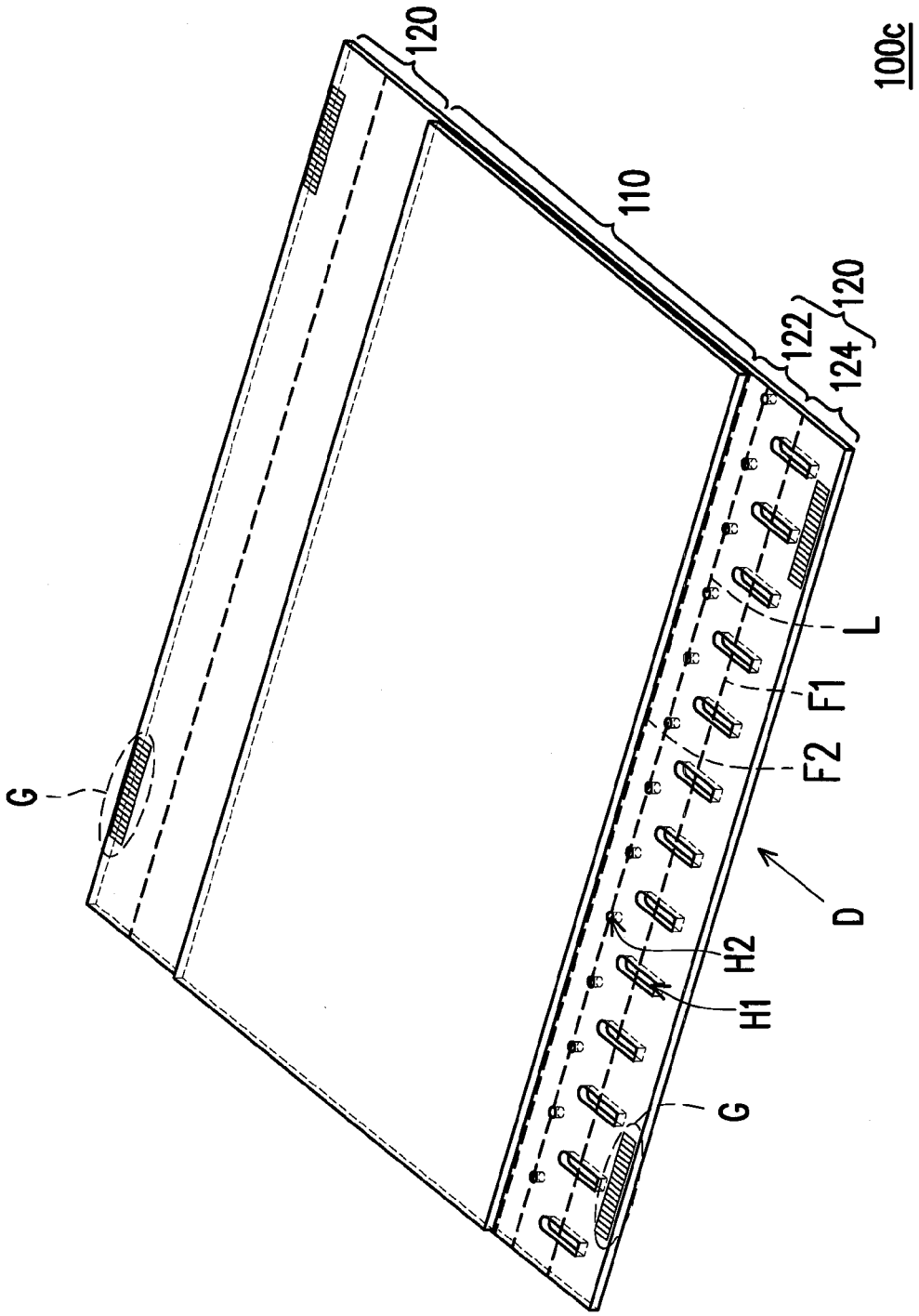

FIG. 6

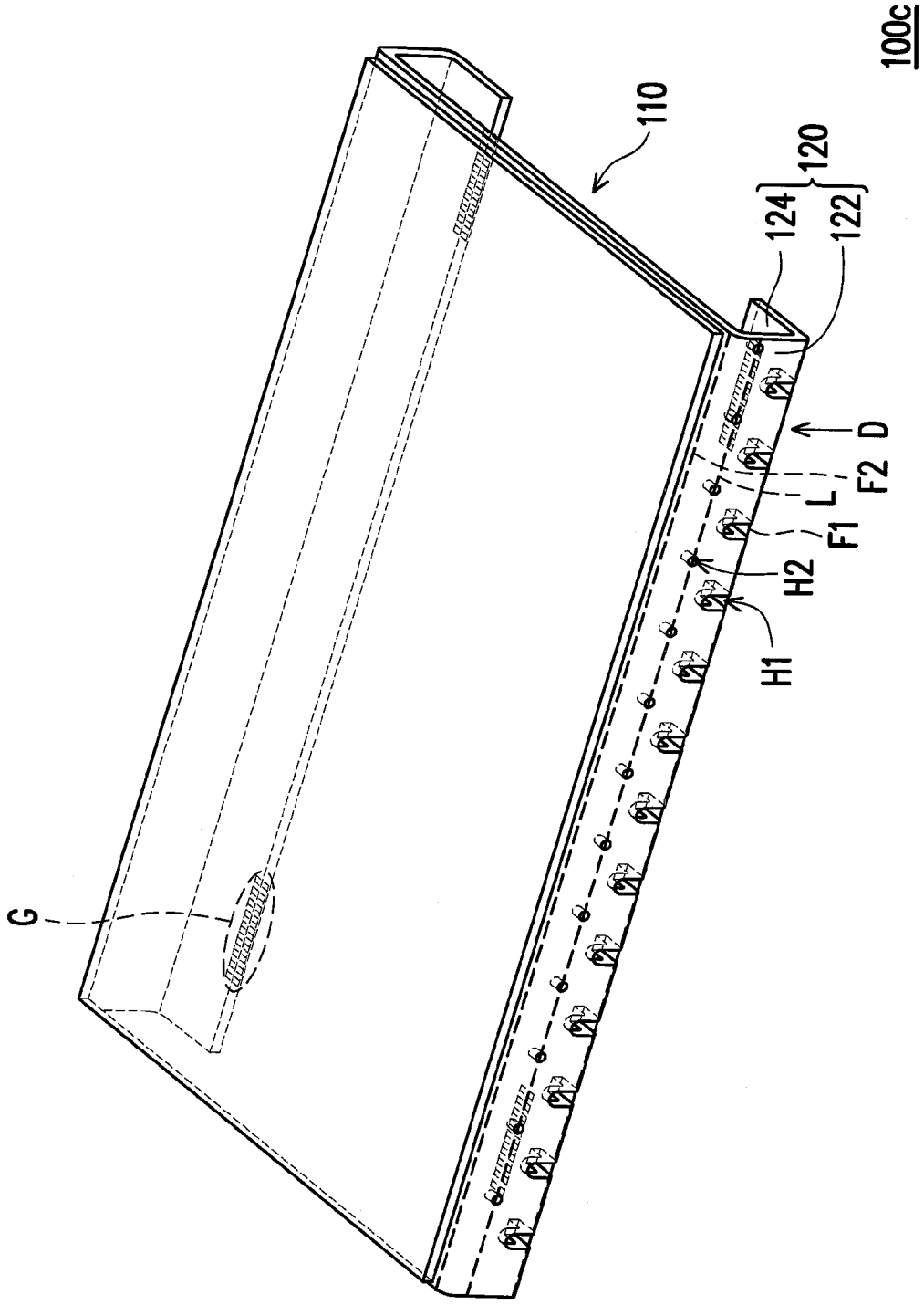

FIG. 7

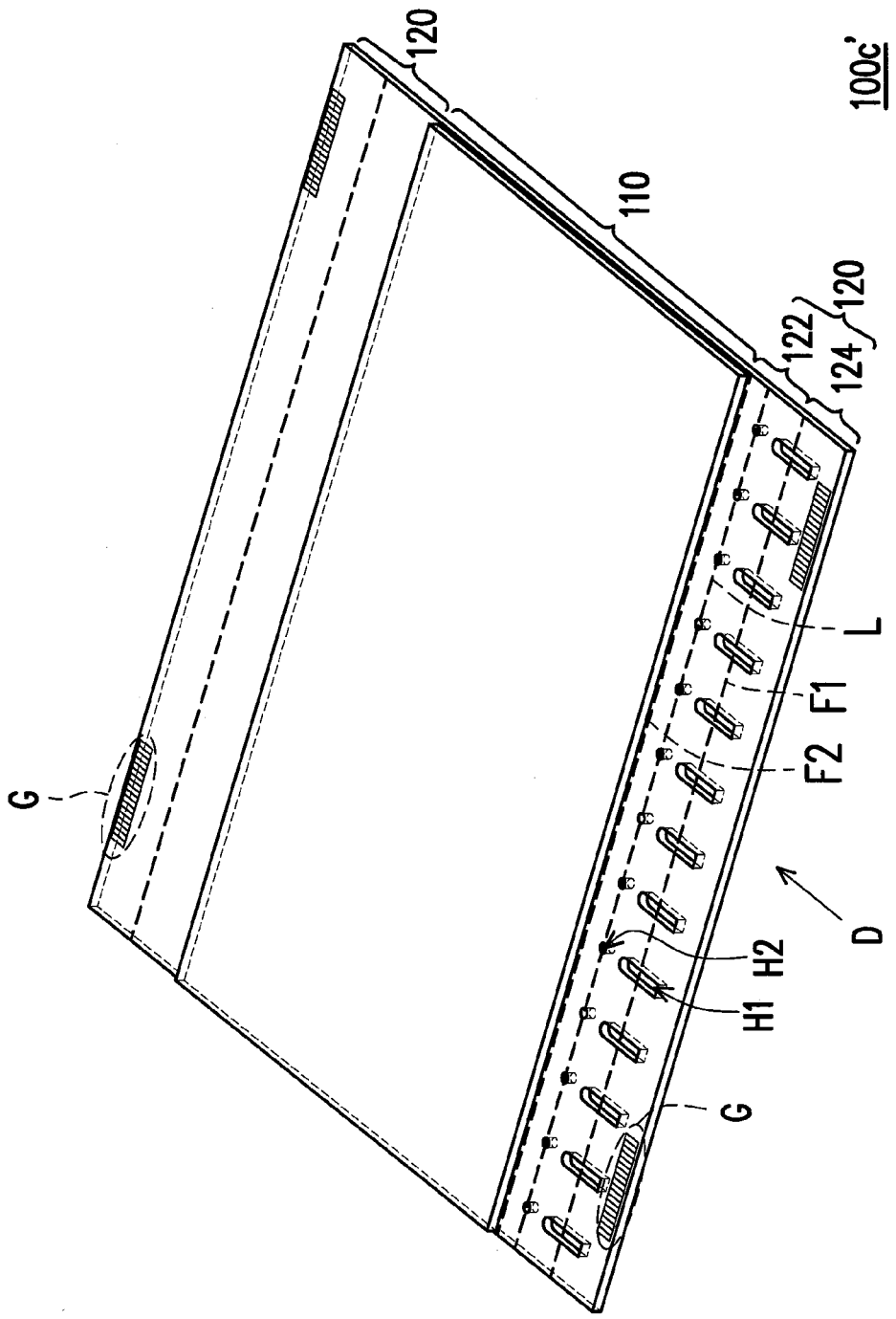

FIG. 8

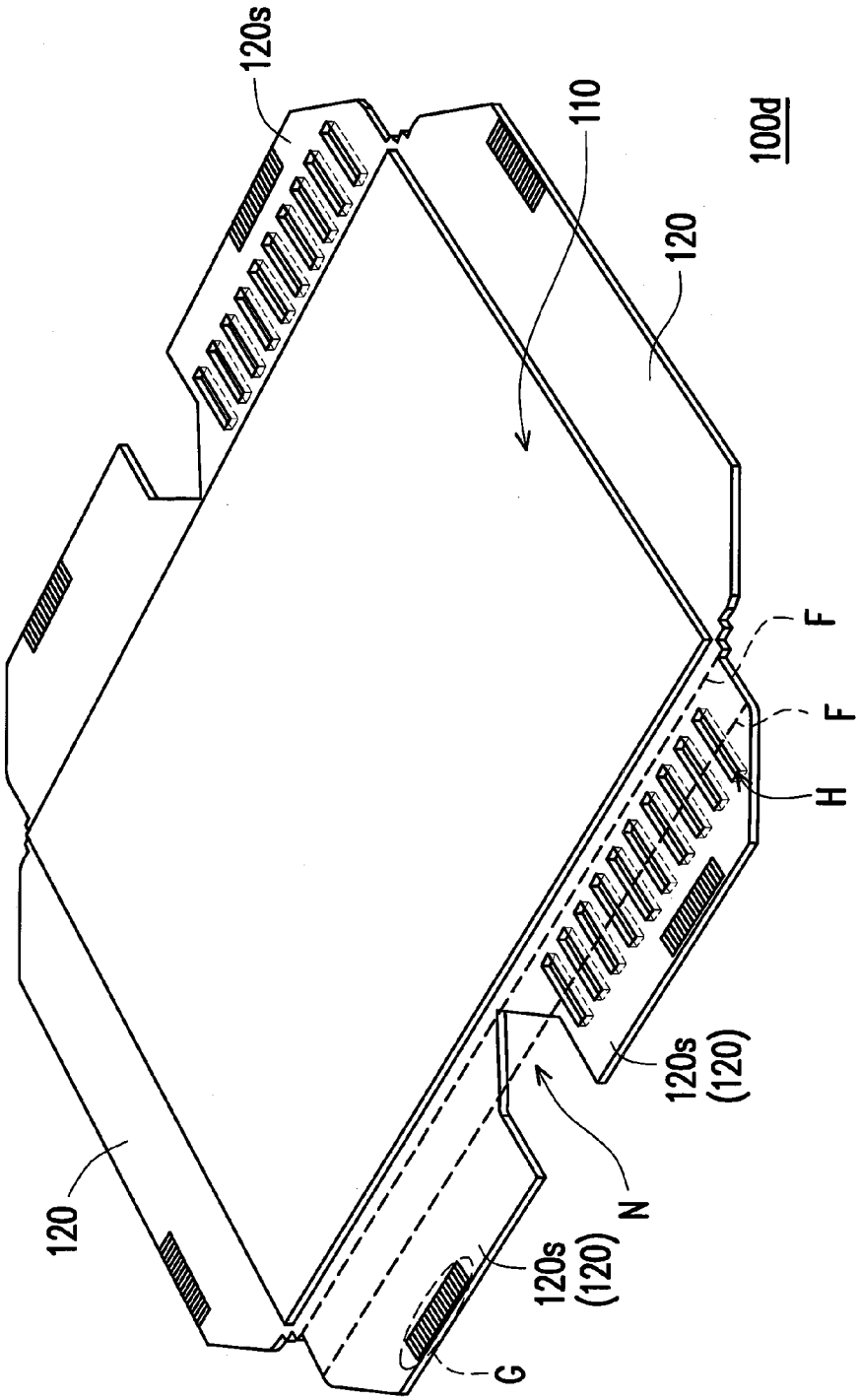

FIG. 9

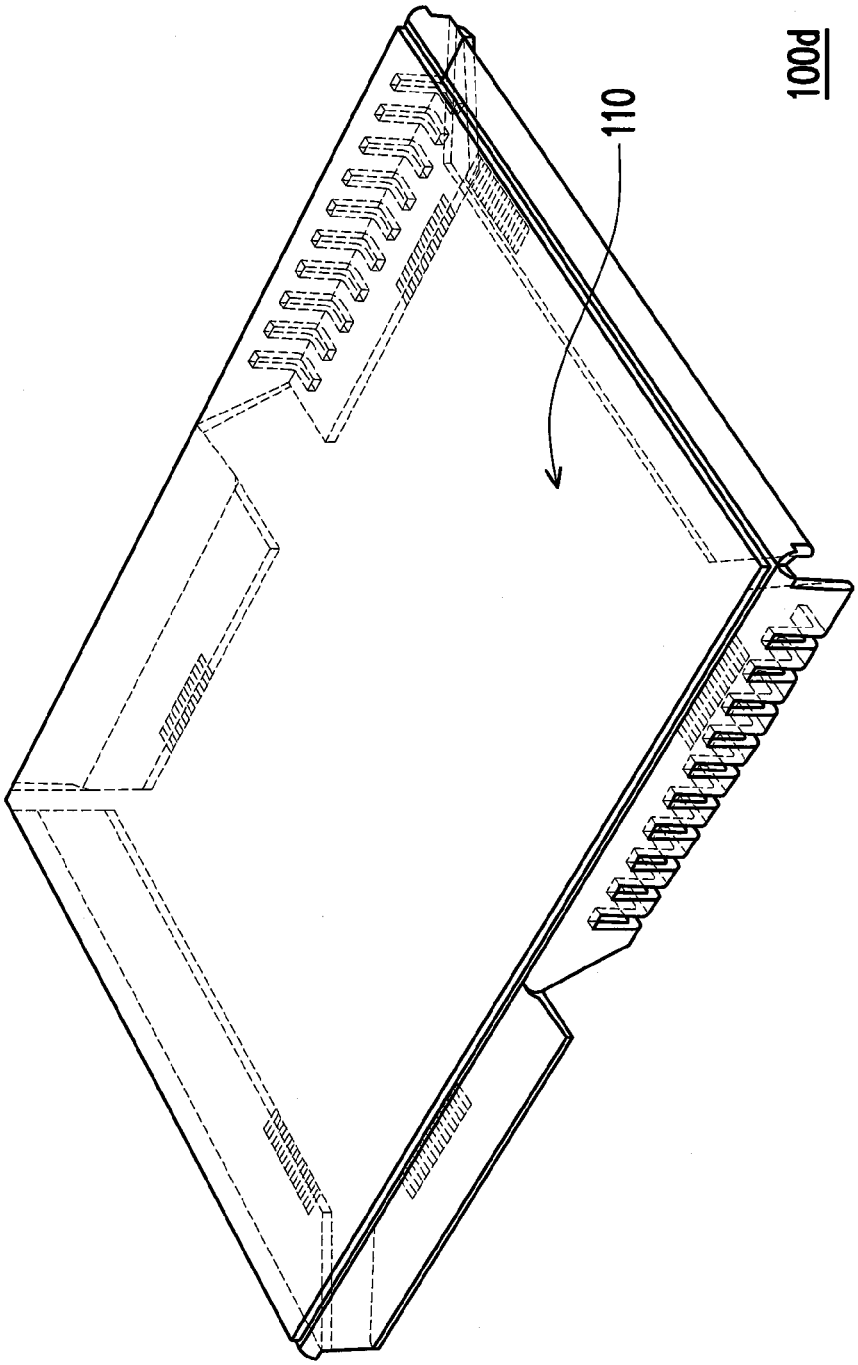

FIG. 10

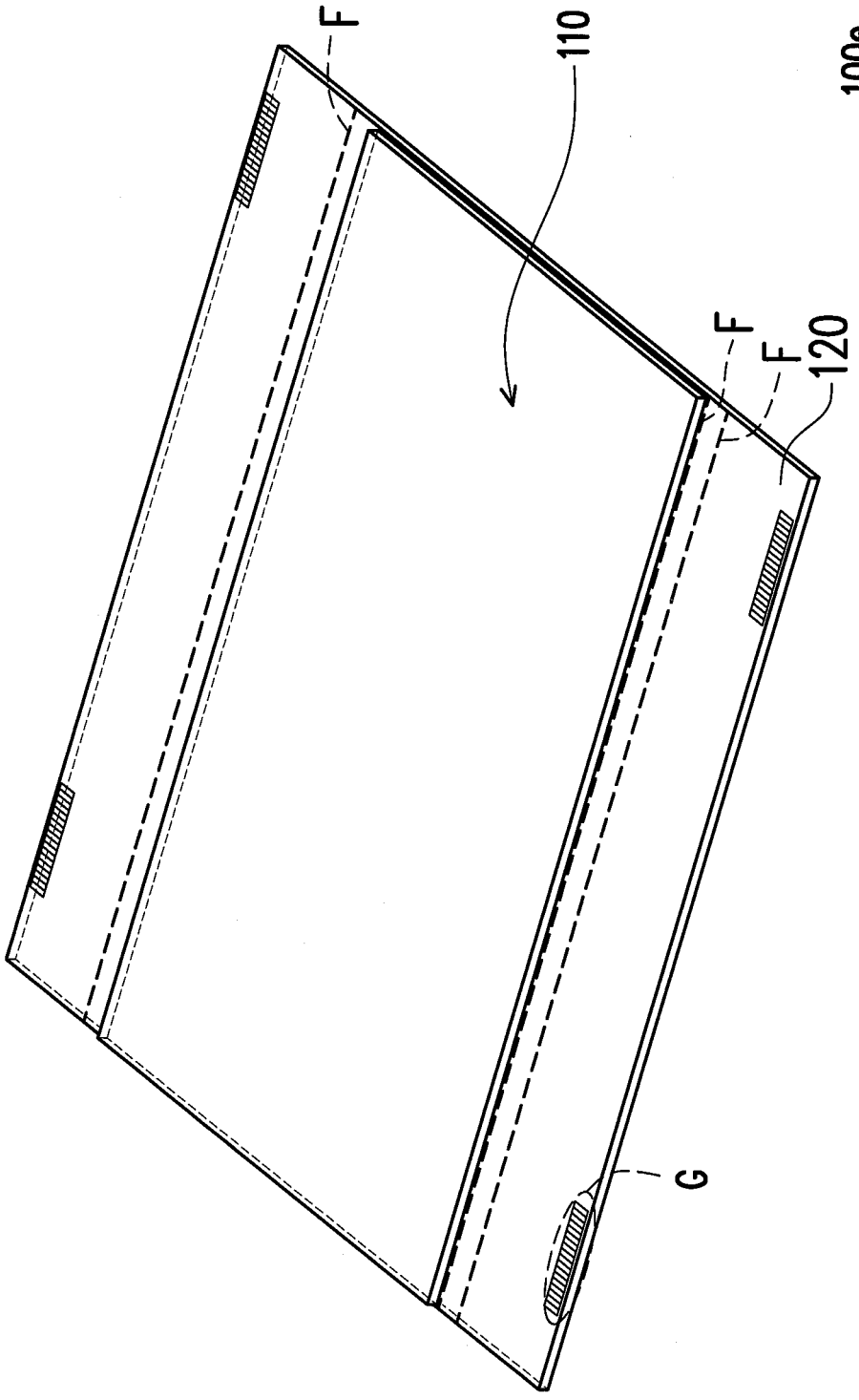

FIG. 11

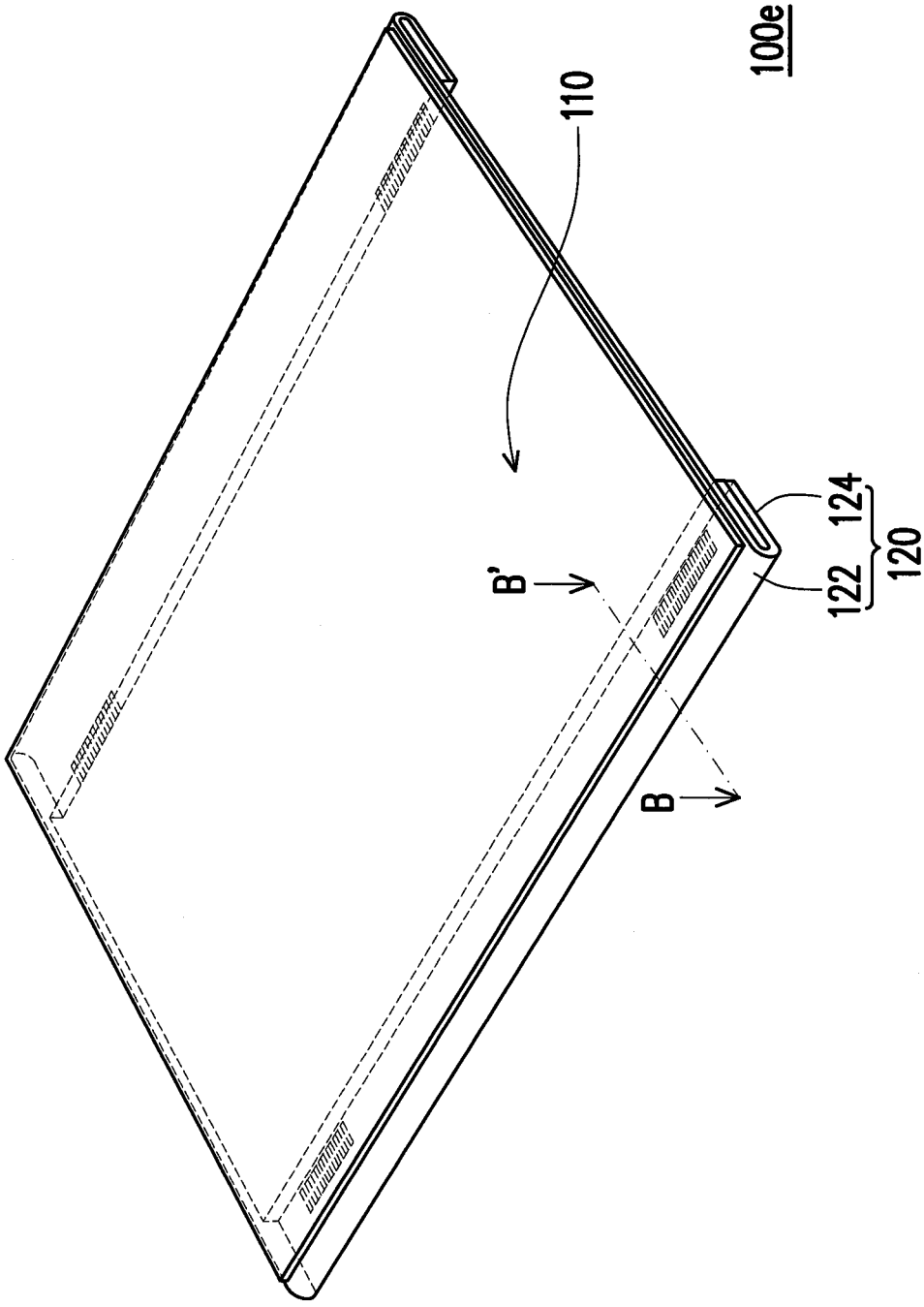

FIG. 12

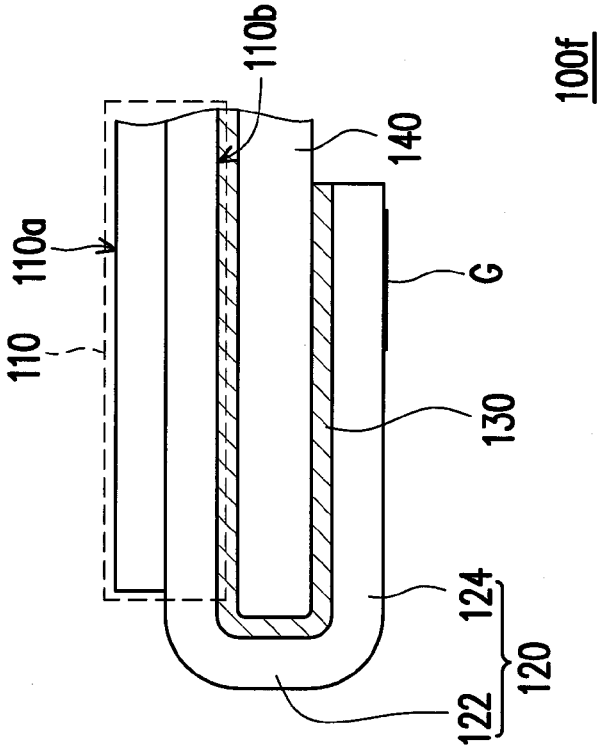
110b
140
100f
110a
G
110
130
124
120
122

FIG. 14

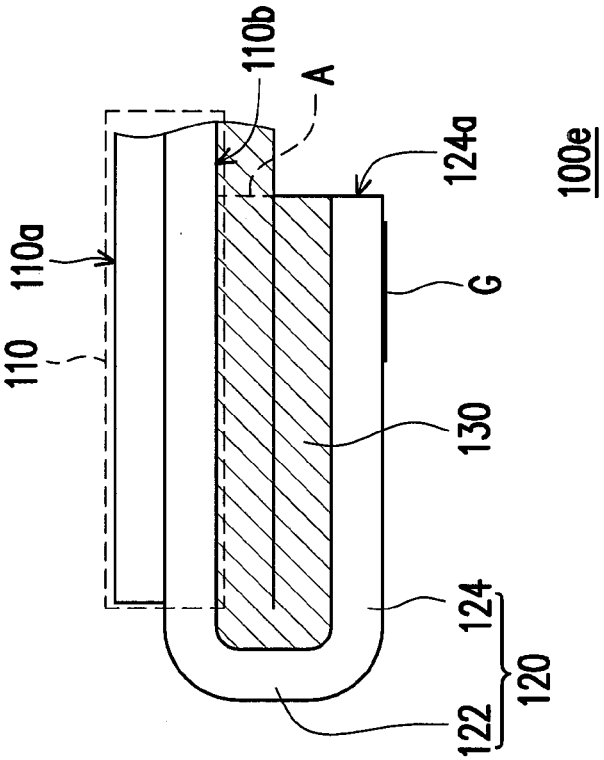
110b
A
124a
100e
110a
G
110
130
124
120
122

FIG. 13

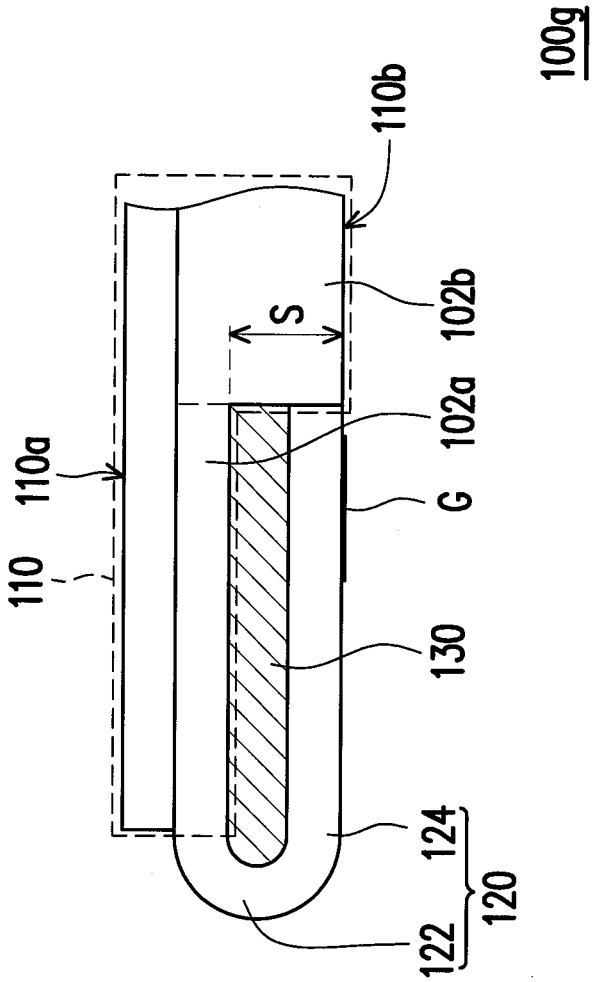

FIG. 15

FLEXIBLE ELECTRONIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefits of U.S. provisional application Ser. No. 61/756,477, filed on Jan. 25, 2013 and Taiwan application serial no. 103101154, filed on Jan. 13, 2014. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of this specification.

TECHNICAL FIELD

The disclosure relates to an electronic component, and a flexible electronic device.

BACKGROUND

Due to a flexible electronic device has features, such as light and thin, flexible, impact resistant, high safety and easy to be carried, the flexible electronic device play a major role in the next generation. Based on the design demand of narrow-edge layout or the signal conduction, the carrier board for the electronic components in a flexible electronic device often gets flexed or bent during assembling.

When the flexible electronic device is bent, the stresses will be concentrated at the bending places of the carrier board which get flexed or bent during assembling so as to lead to the phenomena of stress interference, stress creeping, carrier board's folding, local deformation or destroyed signal contacts (such as an external terminal area). How to take narrow-edge layout and solving the stress concentration into consideration becomes an issue for the technical staff to eagerly concern.

SUMMARY

An embodiment of the disclosure is direct to a flexible electronic device helpful to the design demand of narrow-edge layout and able to reduce stress concentration.

In one embodiment, the flexible electronic device of the disclosure includes a component portion and at least one folded portion connected to the component portion, wherein the flexible electronic device has a plurality of flexed lines located on the single folded portion and a plurality of stress relief holes, the stress relief holes are separated from each other, and at least a part of the stress relief holes is located on at least one of the flexed lines.

In one embodiment, the flexible electronic device of the disclosure includes a component portion and at least one folded portion connected to the component portion, wherein the flexible electronic device has a plurality of flexed lines located on the single folded portion, the folded portion includes a reflexed portion located at the edge of the folded portion, and the reflexed portion is jointed to the component portion.

Based on the depiction above, in the embodiment of the disclosure, the flexible electronic device may meet the design demand of narrow-edge layout even no-edge layout. Further, by disposing a plurality of stress relief holes on the folded portion, the extent of stress concentration can be reduced so as to thereby ensure the quality of the flexible electronic device and increase the lifetime thereof.

Several exemplary embodiments accompanied with figures are described in detail below to further describe the disclosure in details.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic exploded diagram of a flexible electronic device according to an embodiment of the disclosure.

FIG. **2** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **1**.

FIG. **3**A is a cross-sectional diagram along line A-A' in FIG. **2**.

FIG. **3**B is a cross-sectional diagram of a flexible electronic device according to another embodiment of the disclosure.

FIG. **3**C is a cross-sectional diagram of a flexible electronic device according to yet another embodiment of the disclosure.

FIG. **4** is a diagram showing the bent structure of the flexible electronic device of the embodiment.

FIG. **5** is a three-dimensional side-view diagram of a flexible electronic device according to another embodiment of the disclosure.

FIG. **6** is a schematic exploded diagram of a flexible electronic device according to another embodiment of the disclosure.

FIG. **7** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **6**.

FIG. **8** is a schematic exploded diagram of a flexible electronic device according to another embodiment of the disclosure.

FIG. **9** is a schematic exploded diagram of a flexible electronic device according to yet another embodiment of the disclosure.

FIG. **10** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **9**.

FIG. **11** is a schematic exploded diagram of a flexible electronic device according to yet another embodiment of the disclosure.

FIG. **12** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **11**.

FIG. **13** is a cross-sectional diagram along line B-B' in FIG. **12**.

FIG. **14** is a partial cross-sectional diagram of a flexible electronic device according to yet another embodiment of the disclosure.

FIG. **15** is a partial cross-sectional diagram of a flexible electronic device according to yet another embodiment of the disclosure.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENTS

FIG. **1** is a schematic exploded diagram of a flexible electronic device according to an embodiment of the disclosure and FIG. **2** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **1**. Referring to FIGS. **1** and **2**, a flexible electronic device **100***a* includes a component portion **110** and at least one folded portion **120**, in which the folded portion **120** is connected to the component portion **110**.

The flexible electronic device **100***a* is, for example, formed by disposing electronic components on a flexible carrier board and the disclosure does not particularly limit the type of the flexible electronic device **100***a*, for example, the flexible electronic device **100***a* can be a flexible display device. At the time, the component portion **110** can be an organic light emitting diode (OLED), an electrophoretic component, an electrowetting display component or a display component of other types. Taking the OLED as an example of the component portion **110**, the component portion **110** includes a carrier board **102**, an OLED **104** and a cover **106**, as shown in

FIG. **3**A. The OLED **104** is disposed on the carrier board **102** and the cover **106** is disposed on the carrier board **102** and covers the OLED **104**. The area of the carrier board **102** is substantially greater than the area of the cover **106**, in which the area of the carrier board **102** uncovered by the cover **106** comprises the folded portion **120**. FIG. **3**A illustrates an top emitting OLED **104**, which the disclosure is not limited thereto. In other embodiments, the component portion **110** can be a bottom emitting OLED **104** as well, as shown in FIG. **3**B. Or, the component portion **110** can be a double emitting OLED, which is, for example, formed by disposing two OLEDs **104***a* and **104***b* at the two sides of the carrier board **102** and covered respectively by two covers **106***a* and **106***b*, as shown by FIG. **3**C.

The carrier board **102** can have any shapes and is composed of a material with a certain flexibility, for example, plastic, flexible thermoelectric film, flexible thin glass, flexible glass fiberboard, paper, textiles, rubber and resin. The plastic includes polyimide (PI), polyethylene terephthalate (PET) or polyethylene naphthalate (PEN). The cover **106** can have any shapes and is composed of a material with a certain flexibility, for example, plastic, flexible thin glass, flexible glass fiberboard, rubber and resin. The plastic includes polyimide (PI), polyethylene terephthalate (PET) or polyethylene naphthalate (PEN). The cover **106**, preferably, has a certain transparency and can be laminated onto the carrier board **102** by using hot bonding, vacuum lamination, roller lamination or glue lamination.

The OLED **104** may include a plurality of scan lines, a plurality of data lines and a plurality of pixel units, in which each of the pixel units is electrically connected to a corresponding scan line or a corresponding data line. The pixel unit includes, for example, a first electrode, a light emitting material layer and a second electrode, in which the light emitting material layer is located between the first electrode and the second electrode. The pixel unit can use a circuit structure of two transistors with a capacitor (i.e., a so-called 2T1C circuit structure) to drive the above-mentioned OLED **104**, which the disclosure is not limited thereto. The OLED **104** can be driven by using other different circuit. The flexible electronic device **100***a* can include a plurality of signal lines disposed at the folded portion **120**, in which a part of the signal lines is electrically connected to the aforementioned scan lines and data lines. The signal lines extend onto the folded portion **120** to form at least one external terminal region G.

The flexible electronic device **100***a* includes two folded portions **120** connected to the component portion **110**, and the two folded portions **120** are located at the two opposite sides of the component portion **110**, which the disclosure is not limited thereto. In other embodiments, the flexible electronic device **100***a* can include one or three more folded portions **120** and the folded portions **120** can be located at anyone side, any two sides or any three more sides of the component portion **110**.

Taking one folded portion **120** as an example, the flexible electronic device **100***a* has a plurality of flexed lines F located on the folded portion **120**. In the embodiment, the folded portion **120** has two flexed lines F thereon which can be parallel or not parallel to each other. The folded portion **120** is bent along the two flexed lines F to form a side-edge portion **122** and a reflexed portion **124**, and the reflexed portion **124** is located at the edge of the folded portion **120**, in which the component portion **110**, the side-edge portion **122** and the reflexed portion **124** are not coplanar. As shown in FIG. **1**, a process step can be conducted along a flexed line F closer to the component portion **110** so that the component portion **110** and the partial folded portion **120** form an included angle therebetween (for example, 90°), followed by conducting another process step along the other flexed line F so that the partial folded portion **120** is divided into the side-edge portion **122** and the reflexed portion **124** along this flexed line F. The reflexed portion **124** is located at the back of the component portion **110**. The external terminal region G is located on the reflexed portion **124** and faces the direction far away from the component portion **110**. In other words, the joining direction of the external terminal region G gets changed after the process. At the time, the external terminal region G can be even directly jointed to a printed circuit board or a flexible electronic substrate without through a flexible circuit connection board (for example, a flexible printed circuit board) so as to save an operation of joining the flexible circuit connection board. In addition, in the embodiment of the disclosure, the partial carrier board **102** is folded to form the folded portion **120**, which can reduce the frame width of the flexible electronic device **100***a* to realize a design of narrow-edge layout or no-edge layout.

In other embodiments, it can dispose the electronic component of other types on the carrier board **102** to form the component portion **110**, in which the method of disposing the electronic component on the carrier board **102** or connecting the other circuit structures to the external terminal region G includes: connection by connectors, anisotropic conductive paste bonding (ACP), anisotropic conductive film bonding (ACF), soldering, ball grid array packaging and surface mount technology.

The flexible electronic device **100***a* has a plurality of stress relief holes H located on the folded portion **120**, which are separated from each other and located on at least one of the flexed lines F. FIG. **4** is a diagram showing the bent structure of the flexible electronic device of the embodiment. Referring to FIG. **4**, when the flexible electronic device **100***a* is bent, larger stress concentrations easily occur at the place where the bending is bigger, while the folded portion **120** easily suffers a larger stress. Disposing the stress relief holes H is helpful to reduce stress interference, stress creeping, substrate wrinkle, local deformation, destroyed signal contact or other adverse situations. The shape of the stress relief holes H can be any shape such as round, square, trapezoidal and triangular. The opening area of the stress relief hole H is, for example, over 0.25 μm^2 and the type of the stress relief holes H can be a through hole going through the folded portion **120** or a blind hole without going through the folded portion **120**.

The shaping method of the flexible electronic device **100***a* includes die punching, die cutting, knife cutting, laser etching, laser cutting, chemical etching, plasma etching or exposure and development for shaping.

In follows, other embodiments are explained to describe in details the flexible electronic device of the disclosure, wherein the same reference numbers are used in the drawings and the description to refer to the same or like parts but the same technical contents are omitted. FIG. **5** is a three-dimensional side-view diagram of a flexible electronic device according to another embodiment of the disclosure. Referring to FIG. **5**, the structure of a flexible electronic device **100***b* herein is similar to the flexible electronic device **100***a* in FIG. **2** except that at least a part of the stress relief holes H of the flexible electronic device **100***b* pass through both two flexed lines F. The stress relief holes H can, all of them or a part thereof, pass through the two flexed lines F.

FIG.**6** is a schematic exploded diagram of a flexible electronic device according to another embodiment of the disclosure and FIG. **7** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **6**. Referring to FIGS. **6** and **7**, the structure of a flexible electronic device **100***c* herein

is similar to the flexible electronic device **100***a* in FIG. **2** except that the flexible electronic device **100***c* has a plurality of stress relief holes H**1** separated from each other and a plurality of stress relief holes H**2** separated from each other. Each of the stress relief holes H**1** is corresponding to one of the stress relief holes H**2**, wherein the stress relief hole H**1** and the corresponding stress relief hole H**2** are separated from each other. The stress relief holes H**1** are located on one of the flexed lines F**1** without extending onto the other flexed line F**2**. The stress relief holes H**2** are not located on the flexed line F**1** and the flexed line F**2**, and the stress relief holes H**2** are arranged along a straight-line L. The stress relief holes H**1** and the stress relief holes H**2** are not arranged along an arrangement direction D and the arrangement direction D is perpendicular to the straight-line L and the flexed line F**1**. In other words, the stress relief holes H**1** and the stress relief holes H**2** will not simultaneously located on the arrangement direction D perpendicular to the flexed line F**1** so that the stress relief holes H**1** and the stress relief holes H**2** present a dislocation arrangement to increase the structure strength of the folded portion **120**, which the disclosure is not limited thereto.

FIG. **8** is a schematic exploded diagram of a flexible electronic device according to another embodiment of the disclosure. The structure of a flexible electronic device **100***c*' herein is similar to the flexible electronic device **100***c* in FIG. **6** except that in the flexible electronic device **100***c*' of FIG. **8**, the stress relief holes H**1** and the stress relief holes H**2** are arranged along a arrangement direction D. The arrangement direction D is perpendicular to the straight-line L and the flexed line F**1**. In other words, the stress relief holes H**1** and the stress relief holes H**2** are simultaneously located on the arrangement direction D perpendicular to the flexed line F**1** so that the stress relief holes H**1** and the stress relief holes H**2** are aligned with each other along the arrangement direction D.

FIG. **9** is a schematic exploded diagram of a flexible electronic device according to yet another embodiment of the disclosure and FIG. **10** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **9**. Referring to FIGS. **9** and **10**, the structure of a flexible electronic device **100***d* herein is similar to the flexible electronic device **100***a* in FIG. **2** except that the flexible electronic device **100***d* has a notch N. The notch N extends from the edge of the flexible electronic device **100***d* towards the component portion **110** to divide the folded portion **120** into a plurality of sub-areas **120***s*, wherein the stress relief holes H are located on at least one of the sub-areas **120***s*. In the embodiment, the stress relief holes H are located only on one of the sub-areas **120***s*, which the disclosure is not limited thereto. In fact, the stress relief holes H can be located on all of the sub-areas **120***s*. When the flexible electronic device **100***d* is bent, the notch N makes the stresses not concentrated at the area where the notch N is located, which helps to reduce stress interference, stress creeping, substrate wrinkle, local deformation, destroyed signal contact or other adverse situations.

FIG. **11** is a schematic exploded diagram of a flexible electronic device according to yet another embodiment of the disclosure, FIG. **12** is a three-dimensional side-view diagram of the flexible electronic device of FIG. **11** and FIG. **13** is a cross-sectional diagram along line B-B' in FIG. **12**. Referring to FIGS. **11-13**, the structure of a flexible electronic device **100***e* herein is similar to the flexible electronic device **100***a* in FIG. **2** except that the reflexed portion **124** of the folded portion **120** is jointed to the component portion **110**, and the component portion **110** has a front-surface **110***a* and a back-surface **110***b*, in which the reflexed portion **124** is jointed to the back-surface **110***b* of the component portion **110**. The reflexed portion **124** and the component portion **110** can be jointed to each other through a bonding layer **130**. The bonding layer **130** is located between the reflexed portion **124** and the component portion **110**, and the bonding layer **130** entirely overlays the back-surface **110***b* of the component portion **110**. Thus, the flexible electronic device **100***e* can be jointed onto other devices through the bonding layer **130** on the back-surface **110***b* of the component portion **110**, which the disclosure is not limited thereto. In other embodiments, the edge of the bonding layer **130** (referring to the dotted line A in FIG. **13**) can be aligned to the edge **124***a* of the reflexed portion **124**. The bonding layer **130** can be made of, for example, a glue material, a thermoplastic resin or other suitable bonding materials, wherein the thermoplastic resin is, for example, thermoplastic polyimide.

FIG. **14** is a partial cross-sectional diagram of a flexible electronic device according to yet another embodiment of the disclosure. Referring to FIG. **14**, the structure of a flexible electronic device **100***f* herein is similar to the flexible electronic device **100***e* in FIG. **13** except that the flexible electronic device **100***f* further includes a substrate **140**, which is disposed on the back-surface **110***b* of the component portion **110** and located between the reflexed portion **124** and the component portion **110**. The reflexed portion **124**, the component portion **110** and the substrate **140** are jointed together through the bonding layer **130**. The substrate **140** is made of, for example, a flexible material able to provide an appropriate thickness. The folded portion **120** can be bent for wrapping along the edge and the side-wall of the substrate **140** so as to form the reflexed portion **124**. At the time, the folded portion **120** is not easy to wrinkle, crack or other adverse situations due to over-bending.

FIG. **15** is a partial cross-sectional diagram of a flexible electronic device according to yet another embodiment of the disclosure. Referring to FIG. **15**, the structure of a flexible electronic device **100***g* herein is similar to the flexible electronic device **100***e* in FIG. **13** except that the carrier board of the component portion **110** of the flexible electronic device **100***g* includes a first portion **102***a* and a second portion **102***b*. The thicknesses of the first portion **102***a* and the second portion **102***b* are different from each other to form a height step S at the boundary of the first portion **102***a* and the second portion **102***b*. The thickness of the first portion **102***a* is less than the thickness of the second portion **102***b* and the thickness of the first portion **102***a* is roughly equal to the thickness of the folded portion **120**. The first portion **102***a* is adjacent to the folded portion **120** and connected between the second portion **102***b* and the folded portion **120**. When the reflexed portion **124** of the folded portion **120** gets reflexed, a space able to accommodate the reflexed portion **124** is provided since the thickness of the first portion **102***a* is thinner than the second portion **102***b*. The reflexed portion **124** and the first portion **102***a* are jointed together through the bonding layer **130**. The thicknesses of the first portion **102***a* and the reflexed portion **124** after joining are roughly the same as the thickness of the second portion **102***b*. Thus, the flexible electronic device **100***g* is not easy to wrinkle, crack or other adverse situations due to over-bending. The thickness difference between the first portion **102***a* and the second portion **102***b* can be realized by different etching extents, which the disclosure is not limited thereto. In other embodiments, the thickness difference between the first portion **102***a* and the second portion **102***b* can be realized by using other appropriate means.

In summary, the flexible electronic device of the disclosure includes a folded portion to meet the design demand of narrow-edge layout even no-edge layout. Further, by disposing a plurality of stress relief holes on the folded portion, the extent

of stress concentration produced when the flexible electronic device is bent can be reduced so as to ensure the quality of the flexible electronic device and increase the lifetime thereof.

It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure covers modifications and variations of this disclosure and they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A flexible electronic device, comprising a component portion and at least one folded portion connected to the component portion, wherein the flexible electronic device has a plurality of flexed lines located on one of the at least one folded portion and a plurality of stress relief holes, the stress relief holes are separated from each other, and at least a part of the stress relief holes is located on at least one of the flexed lines, and at least a part of the stress relief holes simultaneously passes through two flexed lines.

2. The flexible electronic device as claimed in claim **1**, wherein the flexed lines are parallel to each other.

3. The flexible electronic device as claimed in claim **1**, wherein the flexible electronic device has at least one notch, the notch extends from edge of the flexible electronic device towards the component portion to divide the folded portion into a plurality of sub-areas, wherein the stress relief holes are located at least on one of the sub-areas.

4. The flexible electronic device as claimed in claim **3**, wherein the stress relief holes are located only on one of the sub-areas.

5. The flexible electronic device as claimed in claim **1**, wherein the folded portion and the component portion comprises:

a carrier board;

an organic light emitting device, disposed on the carrier board; and

a cover, disposed on the carrier board and covering the organic light emitting device, wherein area of the carrier board not covered by the cover is the folded portion.

6. A flexible electronic device, comprising a component portion and at least one folded portion connected to the component portion, wherein the flexible electronic device has a plurality of flexed lines located on the single folded portion, wherein the folded portion comprises a reflexed portion located at an edge of the folded portion, and the reflexed portion is jointed to the component portion, wherein the component portion comprises a carrier board, the carrier board comprises a first portion and a second portion, and thickness of the first portion is less than thickness of the second portion.

7. The flexible electronic device as claimed in claim **6**, wherein the reflexed portion is jointed to the component portion through a bonding layer.

8. The flexible electronic device as claimed in claim **7**, wherein the bonding layer is disposed at an area where the reflexed portion and the component portion are overlapped with each other.

9. The flexible electronic device as claimed in claim **7**, wherein the bonding layer overlays a part of the component portion.

10. The flexible electronic device as claimed in claim **7**, wherein the bonding layer entirely overlays the component portion.

11. The flexible electronic device as claimed in claim **6**, further comprising a substrate disposed on the component portion and located between the reflexed portion and the component portion, wherein the reflexed portion, the component portion and the substrate are joined together through a bonding layer.

12. The flexible electronic device as claimed in claim **6**, wherein the first portion is adjacent to the folded portion and connected between the second portion and the folded portion, and the reflexed portion and the first portion are jointed together through a bonding layer.

13. The flexible electronic device as claimed in claim **12**, wherein thickness of the first portion is the same as thickness of the folded portion.

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